Problem SP14. A rigid tank with a volume of 0.7 m³ initially contains moist air at a temperature of 60°C, and a total pressure of 3 bar (state 1). The rigid tank is placed in contact with a 5°C temperature reservoir and is cooled. At a tank temperature of 35°C, liquid water starts to condense (state 2). The cooling process continues until the tank temperature is 5°C (state 3). The surroundings are at $T_0 = 300$ K, $p_0 = 1$ bar.

(a) Find the initial humidity ratio $\omega_1$ and relative humidity $\phi_1$.
(b) Find the mass of liquid water $m_{w3}$ and the mass of water vapor $m_{v3}$ at the final state.
(c) For a control volume with the heat transfer surface inside the 5°C temperature reservoir, determine the exergy destruction $\dot{E}_{d,13}$ for the cooling process.

Problem SP15. A moist air stream enters a heated channel with $m_{a1} = 0.4$ kg/s, $T_1 = 15°C$, and $\phi_1 = 80\%$. The moist air stream exits with $T_2 = 47°C$ and $\phi_2 = 30\%$. The moist air stream flows over a pan of liquid water at a temperature $T_3 = 60°C$ as it moves through the channel. The level of liquid water is kept at a constant level by either supplying or draining water from the pan at a rate $\dot{m}_{w3}$.

(a) Find the mass flow rate of the liquid water, $\dot{m}_{w3}$, in kg/s. Is the flow at section 3 into or out of the channel?
(b) Calculate the rate of heat transfer between the walls of the channel and the moist air stream. Is the heat transfer from the walls to the moist air, or from the moist air to the walls?
Problem SP16. A moist air stream at Section 1 \((T_1 = 30°C, \phi_1 = 30\%)\) enters a heated duct and the temperature increases to \(T_2 = 55°C\) at Section 2. Downstream of Section 2, at section 3, liquid water at a temperature of \(T_3 = 50°C\) is sprayed into the duct and evaporates completely by the time the flow exits the duct at section 4 with temperature \(T_4 = 40°C\). Assume that there is no heat transfer between Sections 2 and 4.

(a) Find the relative humidity \(\phi_2\) of the moist air stream at section 2.
(b) What is the rate of heat transfer to the moist air between Sections 1 and 2 in kJ/sec?
(c) Find the mass flow rate of water \(m_{w3}\) in kg/sec that is sprayed into the duct at section 3 and the relative humidity \(\phi_4\) of the moist air stream at section 4.